

ECOLOGICAL RISK ASSESSMENT OF DEVELOPMENT
& REPLENISHMENT ALONG EASTERN SHORE OF MD

**ECOLOGICAL RISK ASSESSMENT OF COASTAL DEVELOPMENT AND
REPLENISHMENT PROJECTS ALONG THE EASTERN SHORE OF MARYLAND**

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ABSTRACT

Sea level rise coupled with shoreline erosion is a major problem facing much of the Earth's coastlines. In the United States, areas that are particularly susceptible include the Mid-Atlantic region. This paper focuses on the Eastern Shore of Maryland where there is a juxtaposition of intense urban development next to fragile natural coastal ecosystem. Replenishment projects aimed at maintaining beaches and man-made devices are currently used to neutralize the effects of sea level rise which pose risks to human life, animal life, property, and the coastal environment as a whole. While these projects serve human interests in the short run (insofar as they protect man-made structures and human life - at least for now), they do not do anything to help the long-term problem facing developed coastal areas nor do they take into account the affect these projects have on the coastal ecosystem. The policy currently employed utilizes beach replenishment projects as a temporary fix for the problems of beach erosion and shifting coastlines without focusing on long-term policy. The topic of beach replenishment is especially important for those that live on Maryland's Eastern Shore. Alternatives to beach replenishment such as managed retreat and restoration of the coastline to its pre-human state would be more sustainable and also cost less in the long-run than the current policy utilizing beach replenishment.

Introduction

Building along the coastline is a popular and profitable business. In Maryland, there is a total of 3,100 miles of bay and ocean shoreline (Wheeler, 2013). On the Eastern Shore, particularly Ocean City, Maryland, there is more than ten miles of beach, most of which is heavily developed with many residences and businesses. Unfortunately, thought is rarely given to the detrimental effects development may have on the coastal environment and wildlife. An issue that has recently become more pressing is climate change which, most scientists agree, is causing more hurricanes and strong tropical storms due to warming ocean temperatures. The major concern would be loss of human life and property as well as associated costs of rebuilding after these catastrophes. One should also take into account other controversial issues like erosion and sea level rise when conducting risk assessments in exploring different options of sustainability and construction along the Eastern Shore and Ocean City, Maryland.

The Maryland Eastern Shore is a great example of the effects of coastal development on an ecosystem. The ocean shoreline protects the Chesapeake Bay which is one of the largest estuaries found in the United States. The Chesapeake Bay's watershed consists of six states - New York, Pennsylvania, Virginia, West Virginia, Delaware, Maryland, and the entire District of Columbia. The mouth of the Chesapeake Bay is located at the Atlantic Ocean. This causes the health of the Chesapeake Bay and the coastal shoreline of Maryland to be directly connected (Department of Natural Resources, 2013).

Ocean City, which is the largest city found along the shores of Eastern Maryland can be described as "a flat, narrow strip of sand preserved by dunes, beach replenishment, and jetties" (Hazard Mitigation Planning Committee, 2011). The large oceanfront structures, usually temporary and permanent residences like condominiums and hotels, encounter large waves and

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strong winds while structures on the bay are more prone to flood and debris damage.

Unfortunately, unlike oceanfront structures, properties on the bay have little to no protection from jetties, sand dunes, and seawalls that would otherwise disrupt waves and high tides.

(Hazard Mitigation Planning Committee, 2011).

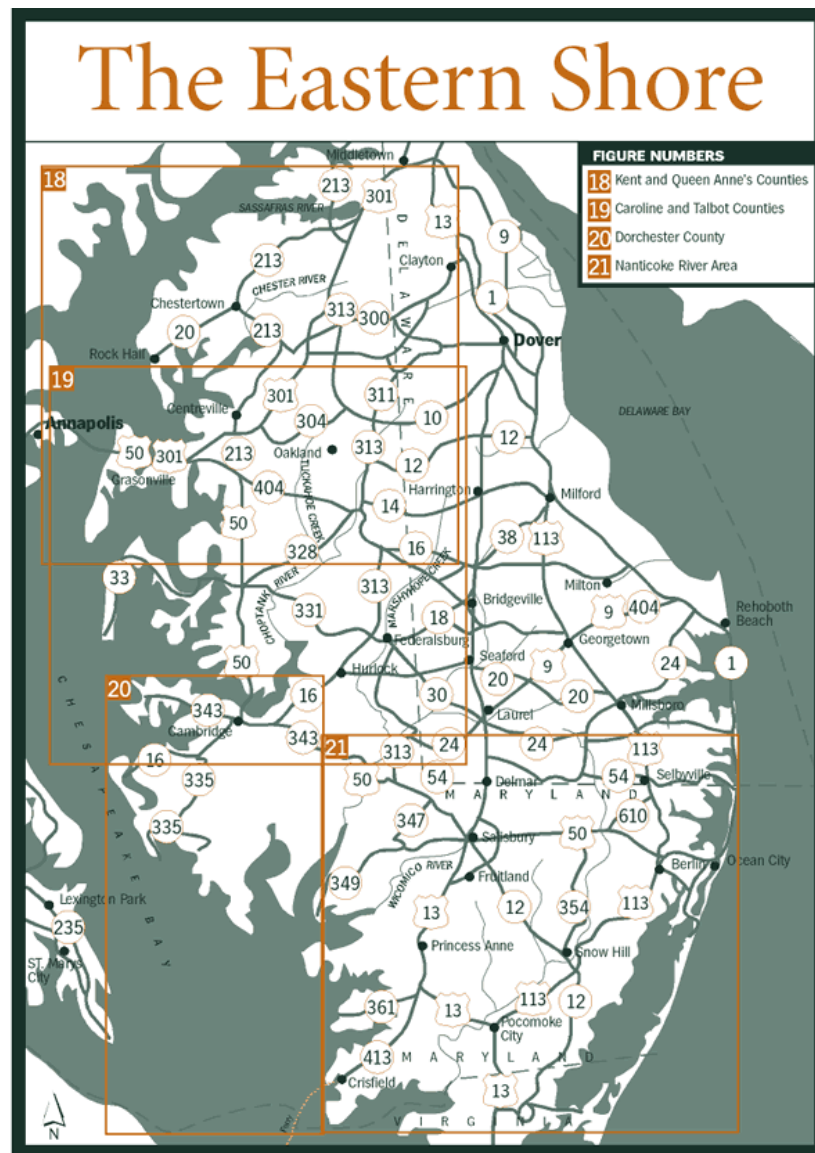


Figure 1. Map of the Eastern Shore of Maryland. This figure shows the Maryland Eastern Shore; important landmarks would be the Chesapeake Bay, which feeds into the Atlantic Ocean and Ocean City located in the bottom right of the map.

One of the most heavily used methods in sustaining Ocean City's oceanfront structures and beaches is beach replenishment or nourishment. Beach replenishment, along with many other man-made structures like jetties and sea walls, is used to curb the effects of erosion while protecting human life and urban development on this barrier island. Beach replenishment projects have many pros and cons that should be taken into consideration. With flooding in this low-lying area of Maryland becoming a recurring problem, mostly due to outdated storm water management practices, other alternatives must be explored to prevent future cataclysms akin to Hurricane Sandy's impact on the Jersey Shore. Alternatives like managed retreat and implementation of "shorefront no-build" areas must be examined using stringent data provided by cost benefit analyses. These measures must then be properly regulated by policymakers.

Climate Change

Climate change is one of the biggest contributing factors to coastal erosion, flooding, and sea level rise (SLR). The "...rising sea levels will increase the risk of floods, and stronger tropical storms [which] may further increase the flood risk" (McGranahan, G., Balk, D., Anderson, B., 2007). Warmer ocean water may also bring about more severe weather, including hurricanes and tropical storms in the coastal regions. Yet building along the shoreline is still continuing and growing rapidly. A 2010 study released by the National Oceanic and Atmospheric Administration (NOAA) stated that 39% of the U.S. population or 123.3 million people live in counties that border the shoreline. The report went on to state that the number of humans living close to the shoreline will increase by "an additional 10 million people or 8% by 2020" (NOAA, 2013). Ocean City, Maryland, has approximately 7,500 year round residents according to the 2010 census; but in the summer months can host up to 350,000 vacationers, with a total of eight

million visitors annually (Hazard Mitigation Planning Committee, 2011). This can pose an obvious risk to human life during a hurricane or severe storm especially due to the already weakened shoreline.

Coastal Erosion, Flooding, and Sea Level Rise

Flooding and erosion are a frequent occurrence for those that live near the coast. Coastal erosion is defined as the removal of land, such as beach and dune sediments, which can be the result of natural or man-made processes (Tarbuck, 2010). Natural phenomena that contribute to coastal erosion are intense waves that are spawned by storms such as tropical cyclones, currents, continental drift and heavy winds which, over time, erode the shoreline. The construction of structures like jetties, while protecting selected areas, cause erosion in others. These structures impact the sediment flow from occurring naturally. In Ocean City, the shoreline is eroding an average of two feet year⁻¹ (Pito, 1992).

Street flooding is also a serious issue as Ocean City's lacks resources and funding for proper storm water management. Drainage systems that are already in place there cannot handle more than two inches of rain per storm. This presents environmental and human health risks where "run-off from the impervious surface goes right into the sewers and ditches and ultimately right into the coastal bays. All of these pollutants, oils, trash, pet waste and metals go right into the bays and then directly into the ocean" (Soper, 2010). The Maryland Department of Natural Resources has predicted a total of 31 repetitive flood loss properties in Ocean City (Hazard Mitigation Planning Committee, 2011).

The rise in sea level also has an impact on the increased erosion of coastlines and can be partially attributed to human activity. An increase in the frequency and intensity of storms coupled with a rise in the sea level can have devastating effects on the coastline. Dr. Marcus

Griswold, who is the Program Coordinator for Climate Change Adaption at the University of Maryland Center For Environmental Science, stated that the Mid-Atlantic coast is especially vulnerable to a rise in the sea level. It has already risen .3 meters over the past 100 years (Griswold, 2013). Sea level rise is a serious problem facing Ocean City, according to a study published by Titus, Leatherman, Dean, Everts, and Kriebel:

Sea level rise could double the rate of erosion at Ocean City in the next forty years. If no additional erosion control measures are taken, the shore will erode 85-153 feet by 2025 assuming current sea level trends. An 11-inch global rise in sea level would increase expected erosion to between 180 and 238 feet, if no additional measures are taken; a 15-inch rise would increase expected erosion to between 216 and 273 feet.

(Titus, Leatherman, Dean, Everts, & Kriebel, 1985, pg. 6).

The risks from coastal erosion, constant flooding, and sea level rise from climate change are major concerns and presents a multitude of problems for the coastal ecosystem.

Beach Replenishment Projects in Ocean City

Projects that are aimed at restoring the beach infrastructure can be approached in different ways, but fundamentally aim to replace the sand on eroding beaches and to rebuild naturally occurring structures including sand dunes, as well as human made structures like buildings on or near a damaged shoreline. Beach replenishment is a part of the overall beach restoration process. Beach replenishment projects are, at their core, a project aimed at maintaining beaches and dealing with erosion of coastal lands. Replenishment programs can become costly over the long-term while not addressing the long-term problems of creating sustainable coasts that have to weather the various effects of natural and man-made problems.

Ocean City, Maryland, the State of Maryland, and Worcester County are currently in a 50-year agreement with the Army Corps of Engineers to perform periodic beach replenishment as needed for proper storm protection. The agreement stipulates that the Army Corps of Engineers is responsible for the design and management of sand dredged from an offshore location to restore beach width. The beach replenishment program includes building of sand dunes, dune crossovers, planting dune sea grasses and erecting fencing next to the seawall along the boardwalk (Town of Ocean City, 2013). The program is completed roughly every four years.



Figure 2. Beach Replenishment in Ocean City. This figure shows beach replenishment being conducted to Ocean City's beachfront, the width of the beach has increased significantly in the first half of the photograph.

Jetties, which are man-made structural devices, are also used to protect Ocean City's beaches. The jetties have stabilized land, particularly at Ocean City's inlet. Though it has affected the movement or transport of sand, according to the U.S. Geological Survey the "...net

longshore drift at Ocean City is southerly; it has [helped to] produce a wide beach at Ocean City north of the jetty, but Assateague Island, south of the inlet, has been starved of sediment” (Watson, 1997). These jetties may protect Ocean City beaches from further erosion by producing wider beach area but it disrupts the natural flow of sediment and could potentially impact the coastal environment downstream at Assateague Island.

Advantages and Disadvantages

Beach replenishment and the use of jetties in Ocean City has helped the coastal area in many ways, but the environmental concerns are striking. An obvious advantage of beach replenishment projects as previously mentioned is the protection of homes, property, and infrastructure by providing a strong buffer against erosion and storms. Typically areas that are replenished prior to storms with “robust dunes and wider beaches [tend to] fare better than compared to those without these projects” (Namiotka, 2013). The use of coastline replenishment projects provide great benefit to humans as these projects have helped maintain the status quo and have increased revenue generated from tourism and recreation. Beaches widened by replenishment projects generally increase tourism by increasing the available ‘towel space’; in turn attracting more visitors to the beach thus leading to increased revenue. Just last year in 2012, Ocean City generated \$3 billion in tourism alone. And the total number of visitors has greatly increased since 2007, about a 26% increase according to reports by The Dispatch (Shriner, 2013). The replenishment projects in Ocean City have so far prevented an estimated \$238 million dollars in storm damage (Town of Ocean City, 2013).

But the beach replenishment program is, in itself a very costly operation since it needs to be repeated periodically to counteract the weakened beach stability. This is very costly, even

with the federal government subsidizing a portion of the cost. The Army Corps of Engineers pays for 53% of the renourishment projects in Ocean City (Town of Ocean City, 2013), with the remaining costs coming from state and local coffers (Parry, 2012). The projected cost for Ocean City's replenishment program is \$81 million for the next 50 years. But it is important to note that the most recently completed project in 2010 cost roughly \$9 million (Conkwright, 2012). The cost of repetitive beach nourishment isn't the only problem with coastal living as there are many environmental risks to be considered.

Environmental Risks

As we continue to develop and engineer alternatives to mitigate soil erosion, beach and watershed habitats are often lost. Earth dikes, bulkheads, and groins often help to mitigate erosion, but in their design, the sandy beaches are often eliminated, causing some spawning habitat to be eliminated (Department of Natural Resources, 2013).

Pollution is considered a secondary impact of development along the Eastern Shore. The Chesapeake Bay Program was developed to research the causes that were contributing to the negative health of the bay. Agricultural runoff is the largest source of pollution within the waterways of the Maryland area. Approximately 32% of the total land in the state of Maryland is utilized for agricultural purposes (Maryland State Archives, 2013). The Chesapeake Bay Research Program found that agriculture was the primary contributor to approximately 42% of the nitrogen, 58% of the phosphorous, and 58% of the sediment into the bay.

These excess nutrients find their way into the waterways through over-irrigation, over-tilling, and the over-application of fertilizers and nutrients. Over-irrigation promotes erosion and pushes excess sediments and nutrients into the groundwater or allows them to run into the streams and rivers. Tilling machines can cause the soil to become compacted and inhibit the

ability for water to penetrate the soil and replenish the groundwater. The compacted soil causes storm water and water from irrigation practices to run directly into streams and rivers. Over-fertilization is when more than the required amount of fertilizer is applied to the field - if more nutrients are applied than can be utilized by the plants, the excess nutrients can either be transported into the ground water or directly into streams and rivers.

The influx of excess nitrogen and phosphorous into the waterway can cause algae blooms which can be extremely harmful to the ecosystem. These algae blooms grow quickly, blocking the bottom of the waterway from sunlight. Once the nutrients are utilized the algae have nothing left to sustain their life and growth. As they die off, the oxygen is depleted. These zones are referred to as dead zones, where marine life cannot be sustained (DNR, 2013).

These excess nutrients can also be exposed to the waterways through the atmosphere. Up to one third of the nitrogen found in the Chesapeake Bay comes from atmospheric deposition. Atmospheric deposition is a process where gases and particulates are released to the atmosphere and settle to the earth as dust, rain, or snow. These gases and particulates are created during combustion from motor vehicle emissions and industrial practices (Chesapeake Bay Program, 2013).

Other Alternatives

Beach replenishment projects are a temporary means that are not an ideal way to maintain stationary shores taking into consideration an expected three foot rise in sea level over the next century, which would require a large amount of financial and natural resources (Oskin, 2013). Constructing jetties and sea walls to hold back the sea will have a minimal effect because it will not allow "...beaches room to move and will ultimately lead to beaches getting squeezed out as

sea level rises...when the rising water reaches a protective wall between the beach and the developed land behind it, the beach is drowned” (Oskin, 2013).

Currently there are many different areas of research that are focusing on ways to manage eroding coastlines. An alternative solution is managed retreat i.e. the movement of structures from areas that suffer high levels of erosion and beach loss, like Ocean City, to areas that are further inland. In order to implement a managed retreat program there would have to be implementation of no-build areas on the shorefront, easements, zoning rules focused on managed retreat, and shoreline setbacks.

Further steps that could be taken for coastal areas prone to erosion would be to expand naturally occurring defenses like wetlands, forests, and beaches in order to provide a buffer for communities (Griswold, 2013). Areas like the Eastern Shore of Maryland need to create and follow adaption plans based on the projected rise in the sea level while also engaging in mitigation planning in order to decrease the amount of greenhouse gases created (Griswold, 2013). Proper planning for possibly inundated shorelines would be a better alternative than beach replenishment projects, which would not even be needed if developments were properly planned to give beaches the room to move naturally in the first place (Oskin, 2013).

Cost Benefit Analysis

Over time, the likely outcome of adhering to current policy for beach community management, especially if there is no preparation for a rise in sea level and stronger storms, is the complete destruction of Ocean City, as depicted in the event tree below.

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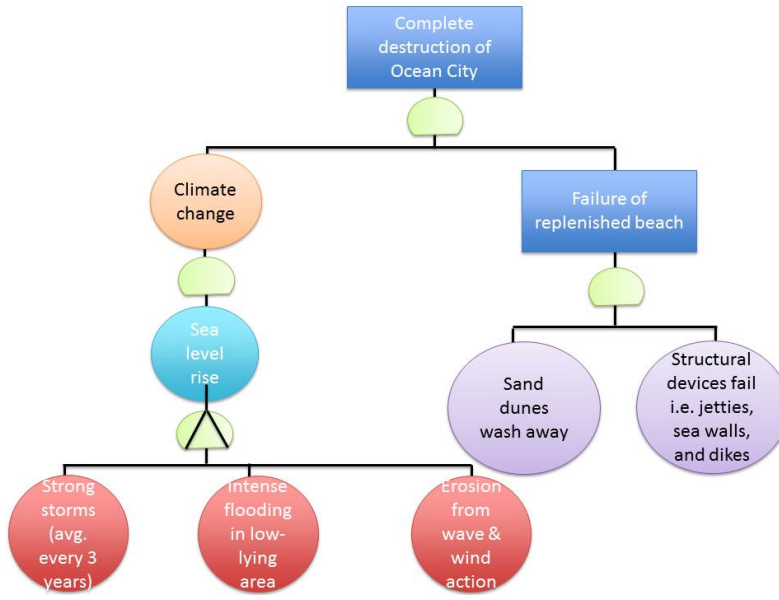


Figure 3. Event Tree. This figure is an event tree depicting the complete destruction of Ocean City if there is little to no preparation for climate change with failures in soft and hard engineering techniques.

As more data is collected, we are seeing that the current policy of beach management is unlikely to be enough as global warming will cause the sea levels to rise, increased shoreline erosion, increased intensity and number of tropical storms, and the possibility of permanent inundation. Serious consideration should be given to the costs and benefits of managed retreat versus staying the course, especially in coastal cities such as Ocean City.

Listed below are the costs and benefits of ‘staying the course’ which is defined as the current policy of beach replenishment with no long-term plan for coping with sea level rise in the near future:

Costs of ‘staying the course’:

- \$81 million spent on beach replenishment
- \$4.8 million in flood loss payments
- \$5,611,586 in hurricane damage

- \$285 million on a program to stop flooding, beach erosion, and coastal damage (Montgomery & Murray, 2012)
- \$10,501,239,662 - the total value of all the building assets in Ocean City in 2010 which would be lost if a total loss when sea levels rise (Hazard Mitigation Planning Committee, 2011)

Benefits of 'staying the course':

- \$3 billion generated for local economy (Hazard Mitigation Planning Committee, 2011)
- \$75 million generated in taxes (Hazard Mitigation Planning Committee, 2011)

Though it is hard to accurately predict the total cost of every variable, such as tourism and revenue generated per year, and the frequency and extent of damage from storms - the costs and benefits can be approximated. The use of current data and calculations from past storms is the basis of this cost-benefit analysis; therefore it is safe to assume that the costs of 'staying the course' outweigh the current benefits.

Over the long run, managed retreat is less costly as coastal structures are allowed to deteriorate or are moved inland. This has been successfully implemented at Pacifica State Beach and at Surfer's Point in California. Although the full costs of relocation, buy-back and soft stabilization procedures are not known, so far these projects promise to cost far less than repeated beach replenishment. A case study published in 2007 by the National Oceanic and Atmospheric Administration, cites project costs at \$2.2 million at Pacifica and \$3.8 million at Surfer's Point.

Managed retreat is politically more palatable and less costly in areas where significant development has not yet occurred. An option for developed areas would be to start a gradual buy-back program, pass legislation that restricts new development, and prohibit re-development of lost structures.

Conclusions

Beach replenishment is a commonly used method in Ocean City to help maintain the coastline, to protect infrastructure and human well-being through the replacement of sand that has eroded away and building of new sand dunes to help protect from future erosion. The downside of these types of projects is the temporary nature of the fix and the recurring costs of implementing it. Beach replenishment projects will not be feasible with the continued rise in sea level resulting from the warming climate. There are clear advantages of replenishment projects but they are weighed down by the disadvantages posed by degradation of the coastal ecosystem. In order to cope with the ever changing situation involving sea level rise, erosion, and flooding new projects have to be implemented and regulations must be updated to prepare the coastline for increased inundation.

An alternative to beach fill and structural projects would be the movement of the Eastern Shores' coastal communities inland. Although relocating communities based on future events cause their own concerns and problems, it is less costly in the long run than beach replenishment or eventual flooding and inundation. Minimization of further coastal development along the Eastern Shore will also reduce pollution to Chesapeake Bay and other coastal waterways. Maryland can emulate other communities who have used partnerships with local, state and federal governments, along with grass-roots and environmental groups, to develop successful and comprehensive shoreline planning programs.

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